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(51) INT CL^6
H01Q 3/26

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H1Q QFA

(56) Documents Cited
GB 2188782 A **GB 2044008 A** **US 5343211 A**
US 4916454 A

(58) Field of Search
UK CL (Edition P) **H1Q QFA QFJ , H4L LFNX**
INT CL^6 **H01Q 3/26**
Online: WPI

(54) Abstract Title
Antenna array arrangement with converging nulls

(57) An antenna array operating method or apparatus comprises an antenna array 102 with a far field radiation pattern which is adapted such that null points in the said radiation pattern converge. The converged null points may be directed such that they attenuate unwanted transmitted and / or received electromagnetic radiation. The nulls may be converged by adapting the amplitude and phase of the antenna array via analogue or digital signal processing. The antenna array may be employed in a base station of a communication system.

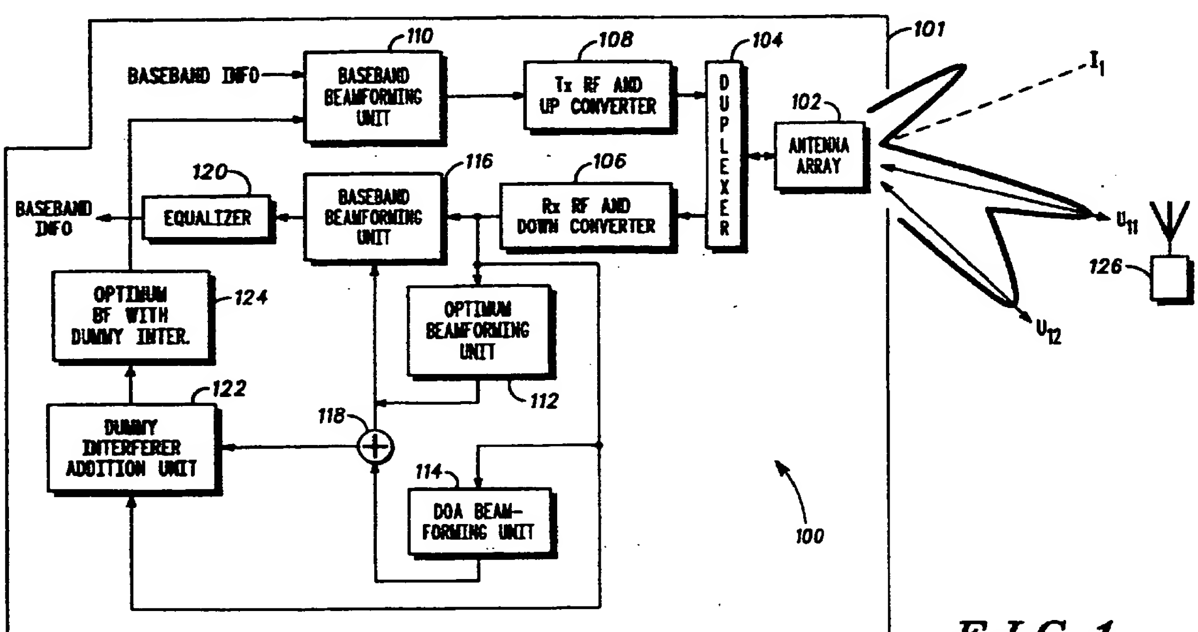

FIG.1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

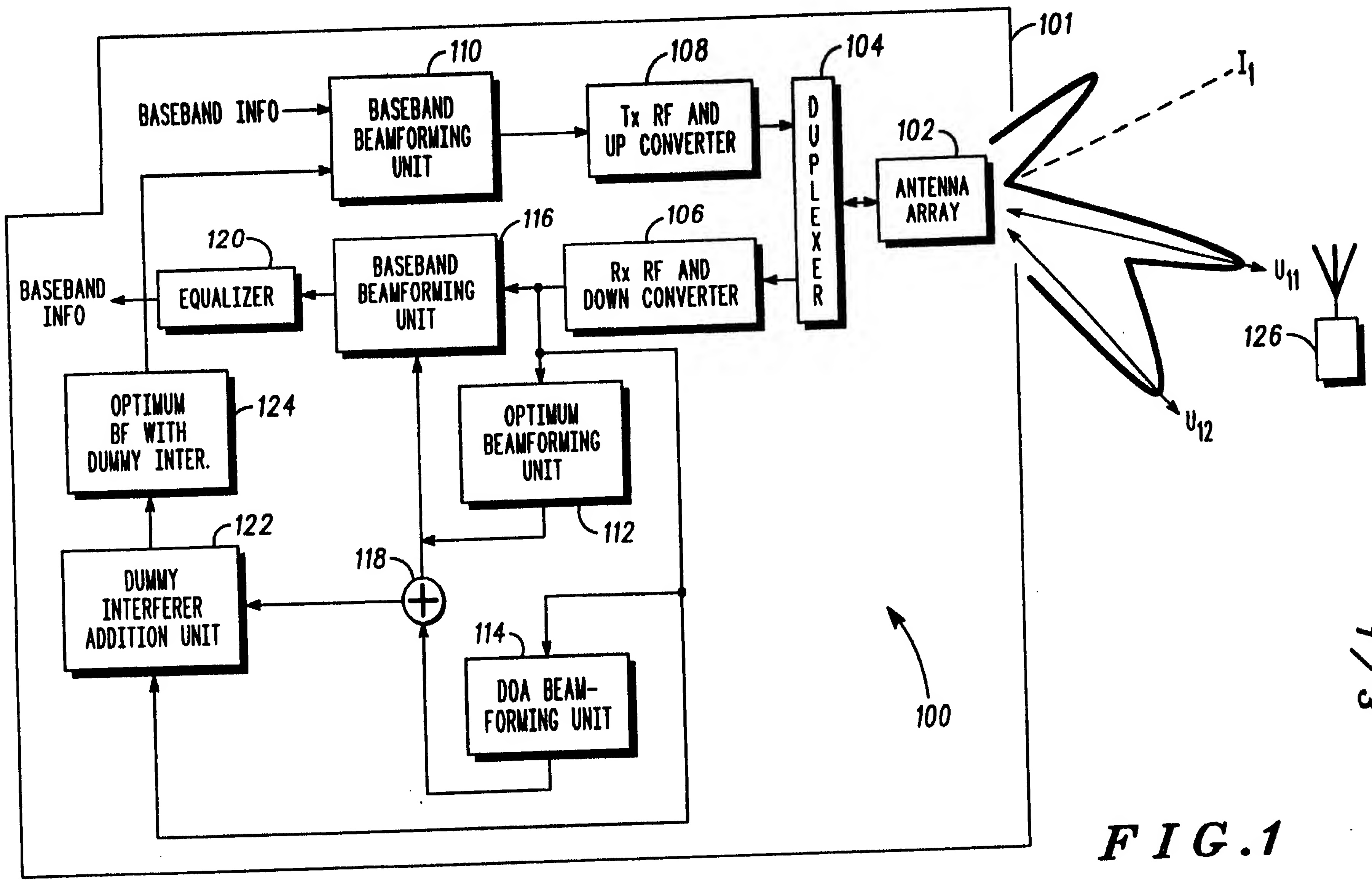
BASEBAND INFO
BASEBAND BEAMFORMING UNIT
110
Tx RF AND UP CONVERTER
108
DUPLEXER
104
ANTENNA ARRAY
102
101
I_1
U_{11}
U_{12}
126
BASEBAND INFO
EQUALIZER
120
BASEBAND BEAMFORMING UNIT
116
Rx RF AND DOWN CONVERTER
106
OPTIMUM BF WITH DUMMY INTER.
124
OPTIMUM BEAMFORMING UNIT
112
DUMMY INTERFERER ADDITION UNIT
122
118
114
DOA BEAM-FORMING UNIT
100

FIG.1

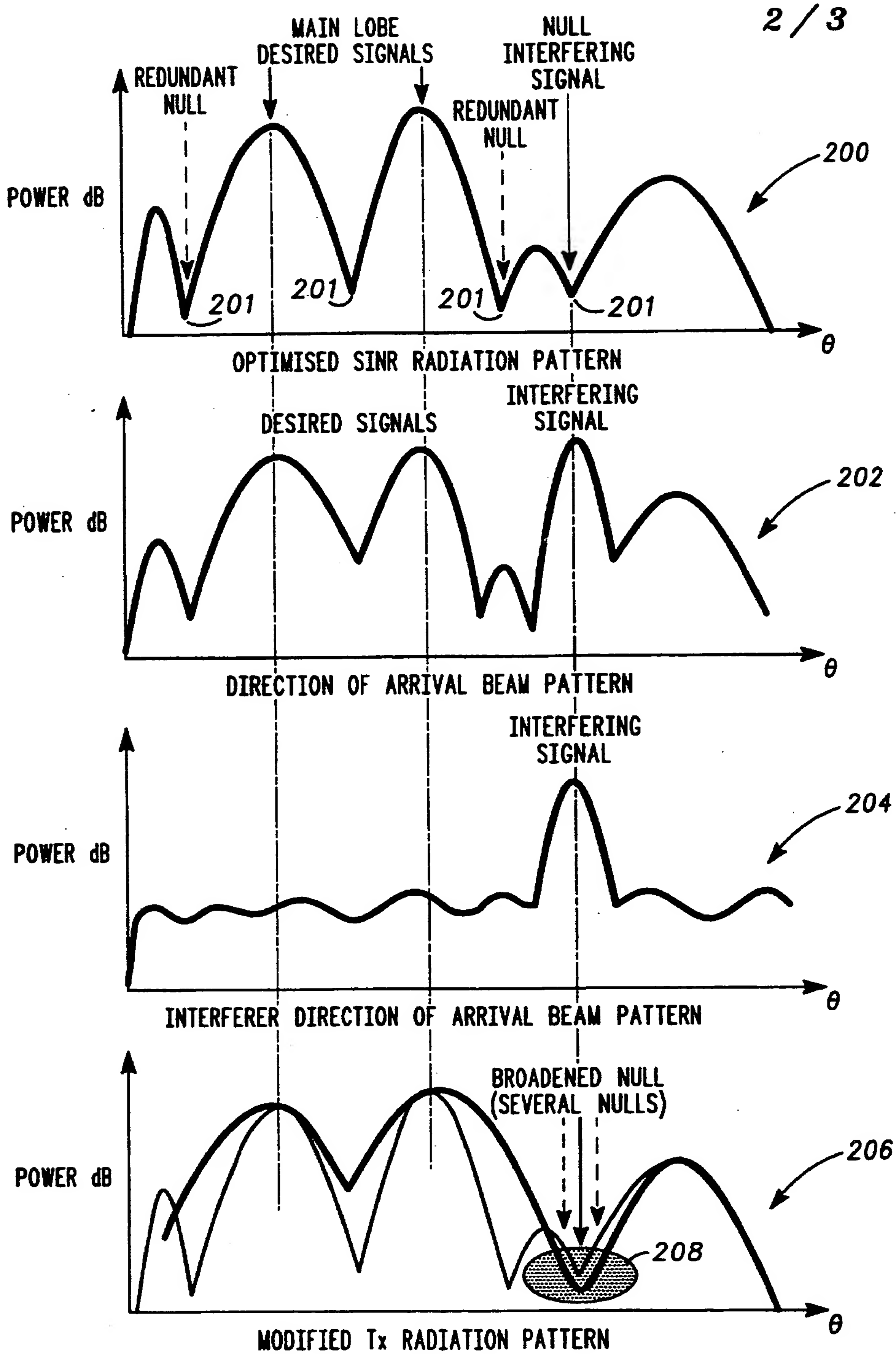
MAIN LOBE
DESIRED SIGNALS
NULL
INTERFERING
SIGNAL
REDUNDANT
NULL
REDUNDANT
NULL
POWER dB
201
201
201
201
200
θ
OPTIMISED SINR RADIATION PATTERN
INTERFERING
SIGNAL
DESIRED SIGNALS
POWER dB
202
θ
DIRECTION OF ARRIVAL BEAM PATTERN
INTERFERING
SIGNAL
POWER dB
204
θ
INTERFERER DIRECTION OF ARRIVAL BEAM PATTERN
BROADENED NULL
(SEVERAL NULLS)
POWER dB
206
208
θ
MODIFIED Tx RADIATION PATTERN

FIG.2

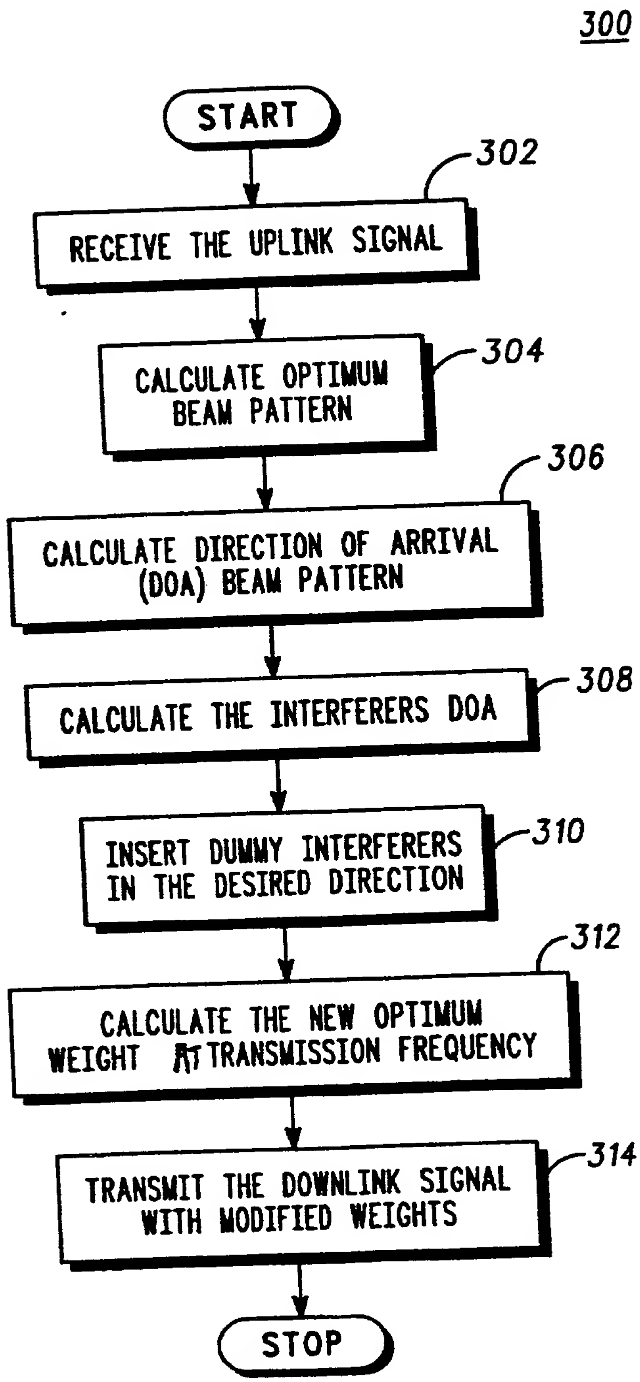
300
START
302
RECEIVE THE UPLINK SIGNAL
304
CALCULATE OPTIMUM BEAM PATTERN
306
CALCULATE DIRECTION OF ARRIVAL (DOA) BEAM PATTERN
308
CALCULATE THE INTERFERERS DOA
310
INSERT DUMMY INTERFERERS IN THE DESIRED DIRECTION
312
CALCULATE THE NEW OPTIMUM WEIGHT AT TRANSMISSION FREQUENCY
314
TRANSMIT THE DOWNLINK SIGNAL WITH MODIFIED WEIGHTS
STOP

FIG.3

ANTENNA ARRAY AND METHOD THEREFOR

Field of the Invention

The present invention relates to an antenna array of the type used in a communications system, for example, a cellular telecommunications system, such as a Global System for Mobile Communications (GSM) network. The present invention also relates to a method of generating a far field radiation pattern for the antenna array.

Background of the Invention

It is known in the art to employ an adaptive antenna array in a cellular communications system. Typically, the adaptive antenna array comprises an array of antennas coupled to a beamforming network in order to generate a far field radiation pattern.

The far field radiation pattern includes a series of null points independently located therein.

However, due to the nature of the null points, a relatively small point in the far field radiation pattern is occupied. It is therefore difficult to effectively attenuate undesirable transmitted signals from the antenna array so as not to cause interference to a given mobile terminal. This is due to the movement of the given mobile terminal and movement of sources of electromagnetic scattering.

It is therefore an object of the present invention to obviate or mitigate the above mentioned disadvantages in relation to adaptive antenna arrays.

Summary of the Invention

According to a first aspect of the present invention, there is provided an antenna array comprising a plurality of antennas having a far field radiation pattern and a complex signal modifying unit for modifying the shape of the

far field radiation pattern, wherein the complex signal modifying unit is adapted to converge a plurality of null points within the far field radiation pattern of the plurality of antennas.

According to a second aspect of the present invention, there is provided a base station comprising an antenna array including a plurality of antennas having a far field radiation pattern and a complex signal modifying unit for modifying the shape of the far field radiation pattern, wherein the complex signal modifying unit is adapted to converge a plurality of null points within the far field radiation pattern of the plurality of antennas.

According to a third aspect of the present invention, there is provided a method of generating a far field radiation pattern for an antenna array, the method comprising the steps of:

providing a complex signal modifying unit for modifying the shape of the far field radiation pattern, and

altering the parameters of the complex signal modifying unit so as to converge a plurality of null points within the far field radiation pattern of the antenna array.

It is thus possible to provide an antenna array and a method therefor which is able to attenuate undesirable signals more effectively.

Other, preferred, features and advantages are set forth in, and will become apparent from, the following description and the appended dependent claims.

Brief Description of the Drawings

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a schematic representation of an apparatus constituting an embodiment of the present invention;

FIG. 2 is a schematic diagram of antenna radiation patterns relating to the apparatus of FIG. 1, and

FIG. 3 is a flow diagram of the operation of the embodiment of FIG. 1.

Description of a Preferred Embodiment

A base station 101 (FIG. 1) in a communications system (not shown) includes, inter alia, an adaptive antenna transmitter receiver chain 100, or transceiver. The adaptive antenna transmitter receiver chain 100 (FIG. 1) comprises an antenna array 102 coupled to a duplexer 104. The duplexer 104 is coupled to a Radio Frequency (RF) transmitter and up-converter 108 and an RF receiver and down-converter 106, the RF transmitter and up-converter 108 being coupled to a baseband beamforming unit 110 having an input terminal for modulated signals to be transmitted. The RF receiver and down-converter 106 is coupled to an optimum reception beamforming unit 112, a direction-of-arrival beamforming unit 114 and a baseband beamforming unit 116, each of which are connected to a summing unit 118. The RF receiver and down-converter 106 is also coupled to a "dummy" interferer addition unit 122. The baseband beamforming unit 116 is coupled to an equaliser 120 having an output terminal.

The summing unit 118 is coupled to a "dummy" interferer addition unit 122 which is coupled to an optimum beamforming unit 124. The optimum beamforming unit 124 is coupled to the baseband beamforming unit 110. Together, the summing unit 118, the "dummy" interferer addition unit 122 and the optimum beamforming unit 124 form a complex signal modifying unit. The complex signal modifying unit can include a digital signal processing unit or a phase and amplitude modifier.

Operation of the above apparatus will now be described with reference to FIGs. 2 and 3. The operation of the invention will, for simplicity and clarity of description, only be described in the context of transmission of signals using the adaptive antenna array 102.

A first and second uplink signal u_{11}, u_{12}, constituting multipath signals, is received (step 302) by the RF receiver and down-converter 106 via the antenna array 102 and the duplexer 104. The first and second uplink signals u_{11}, u_{12} are received from a mobile terminal 126, receipt of transmissions from which is desirable.

The optimum beamforming unit 112 then generates (step 304) an optimum beamforming pattern 200. The optimum beamforming pattern 200 is a far field radiation pattern shaped so as to provide gain for signals, the receipt of which is desired, whilst attenuating unwanted signals. The signal is most attenuated at the location of null points 201 in the far field radiation pattern.

Either sequentially or in parallel, the direction-of-arrival beamforming unit 114 generates (step 306) a Direction of Arrival (DOA) beam pattern 202. The DOA beam pattern 202 is a far field radiation pattern corresponding to all electromagnetic radiation received by the antenna array 102.

The optimum beamforming pattern 200 is then subtracted (step 308) from the DOA beam pattern 202 by the summing unit 118 in order to generate an interferer far field radiation pattern 204 having a main lobes corresponding to the existence of an undesired, or interfering, signal I_1. Similarly, it is also undesirable to cause interference to the source of the interfering signal I_1, for example, another mobile terminal (not shown), when transmitting using the adaptive antenna array 102.

The interferer far field radiation pattern 204 is then received by the "dummy" interferer addition unit 122 which generates a modified signal by modelling a predetermined number of additional interference sources. The additional interference sources corresponding to "dummy" sources of interference and are superimposed on the signal received from the RF receiver and down-converter 106.

The modified signal is then processed by the optimum beamforming unit 124 in order to calculate (step 312) a new set of antenna weights for generating a new far field radiation pattern 206 having null points 208 converging in a

region of the new far field radiation pattern 206 corresponding to the location of the interfering signal I_1 in the interferer far field radiation pattern 204.

Downlink signals are then transmitted by the adaptive antenna array 102 using the new set of weights (step 314).

Due to the convergence of the null points 208, it is thus possible to form a far field radiation pattern having a reduced probability of causing interference to other mobile terminals substantially immune to movements of the other mobile terminals or movements of sources of electromagnetic scattering.

Claims

1. An antenna array comprising a plurality of antennas having a far field radiation pattern and a complex signal modifying unit for modifying the shape of the far field radiation pattern, wherein the complex signal modifying unit is adapted to converge a plurality of null points within the far field radiation pattern of the plurality of antennas.

2. An antenna array as claimed in Claim 1, wherein the plurality of null points converge within the far field radiation pattern so as to attenuate unwanted received radiation.

3. An antenna array as claimed in Claim 1, wherein the plurality of null points converge within the far field radiation pattern so as to attenuate unwanted transmitted radiation.

4. An antenna array as claimed in any one of the preceding claims, wherein the null points are converged by modifying the amplitude and phase of the antenna array in the analogue domain.

5. An antenna array as claimed in Claim 4, wherein the complex signal modifying unit is a phase and amplitude modifier.

6. An antenna array as claimed in any one of the preceding claims, wherein the null points are converged by modifying the amplitude and phase of the antenna array in the digital domain.

7. An antenna array as claimed in Claim 6, wherein the complex signal modifying unit is a digital signal processing unit.

8. An antenna array as claimed in any one of the preceding claims, wherein the radiation is electromagnetic radiation.

9. A method of generating a far field radiation pattern for an antenna array, the method comprising the steps of:

providing a complex signal modifying unit for modifying the shape of the far field radiation pattern, and

altering the parameters of the complex signal modifying unit so as to converge a plurality of null points within the far field radiation pattern of the antenna array.

10. A base station comprising an antenna array including a plurality of antennas having a far field radiation pattern and a complex signal modifying unit for modifying the shape of the far field radiation pattern, wherein the complex signal modifying unit is adapted to converge a plurality of null points within the far field radiation pattern of the plurality of antennas.

11. An antenna array substantially as hereinbefore described with reference to FIGs. 1 and 2.

12. A method of generating a far field radiation pattern substantially as hereinbefore described with reference to FIG. 3.

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Application No: GB 9718192.9
Claims searched: 1 - 12

Examiner: J. A. Watt
Date of search: 14 January 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H1Q (QFA, QFJ); H4L (LFNX)

Int Cl (Ed.6): H01Q 3/26

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2188782 A	(STC) see page 1, lines 5 - 15	1, 9 & 10 at least
A	GB 2044008 A	(FORD AEROSPACE) see page1, lines 3 - 29 and page 2, lines 59 - 78	1, 9 & 10 at least
A	US 5343211	(GEC) see Figs.1 - 16 and col.10, lines 52 - 62	1, 9 & 10 at least
A	US 4916454	(ALLIED-SIGNAL) see col.1, lines 7 - 11	1, 9 & 10 at least

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Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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